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Multi-attribute utility analysis using the Mark Johnson model in defense contracting

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THESIS

MULTI-ATTRIBUTE UTILITY ANALYSIS USING THE MARK JOHNSON MODEL IN DEFENSE CONTRACTING

by

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June, 1995

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This study attempted to determine how the Mark Johnson model for utility maximization in a multi-attribute environment could be used in DOD contracting to increase the overall gain or benefit to the government. It was established that as the Department of Defense budget decreases, increased emphasis has been placed on acquisition reform. In order for the reforms to achieve an efficient solution, the objectives the military should be accomplishing can not be overlooked. The Mark Johnson model was introduced as a mechanism that examined all of the critical areas that impact effectiveness and provided a means for maximizing this effectiveness in the most efficient way. The study indicated four areas in which the examination of multiple attributes via the Mark Johnson mechanism could prove beneficial to the government. The research also examined the criteria for selecting key attributes and the methodolgy for determining their tradeoff values. The research concluded that in the presence of adequate competition, this mechanism could prove to be a valuable addition to the acqusition workforces toolbox.

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Multi-attribute Utility Analysis Using the Mark Johnson Model in Defense Contracting

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ABSTRACT

This study attempted to determine how the Mark Johnson model for utility maximization in a multi-attribute environment could be used in DOD contracting to increase the overall gain or benefit to the government. It was established that as the Department of Defense budget decreases, increased emphasis has been placed on acquisition reform. In order for the reforms to achieve an efficient solution, the objectives the military should be accomplishing can not be overlooked. The Mark Johnson model was introduced as a mechanism that examined all of the critical areas that impact effectiveness and provided a means for maximizing this effectiveness in the most efficient way. The study indicated four areas in which the examination of multiple attributes via the Mark Johnson mechanism could prove beneficial to the government. The research also examined the criteria for selecting key attributes and the methodolgy for determining their tradeoff values. The research concluded that in the presence of adequate competition, this mechanism could prove to be a valuable addition to the acqusition workforces toolbox.

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I. INTRODUCTION

A. BACKGROUND

As the Department of Defense (DOD) budget decreases, increased emphasis has been placed on acquisition reform. The idea behind this reform is to streamline the acquisition process in order to receive the largest possible gain from the funds that are spent. Unfortunately, the drive to reduce funds has often occurred at the expense of being able to carry out the mission. In order for the reforms to achieve an efficient solution, the object of what we should be accomplishing can not be overlooked. Only by examining all of the critical areas that impact the effectiveness of DOD expenditures can the utility or overall gain of the government be maximized. This thesis studies mechanisms that consider multiple attributes in this gain maximization focusing specifically on the work done by Mark Johnson.

The economic model developed by Mark Johnson attempts to maximize the effectiveness of DOD expenditures by clearly defining the key attributes that give benefit to the government and allowing flexibility in the achievement of those attributes. [Ref. 1]

B. OBJECTIVE

This study focuses on analyzing the criteria necessary for realistically using the Mark Johnson model for increasing both the effectiveness and efficiency of DOD expenditures. It also discusses the use of other multi-attribute models and the criteria required for their implementation.

C. THE RESEARCH QUESTION

The principal research question was: How can the Mark Johnson model be used in DOD contracting to increase the overall gain to the government?

Subsidiary research questions were:

1. What attributes should be considered key to a project?

2. How can a relationship between the key elements be defined?

3. Will streamlined contracting methods affect the availability of DOD contractors in the long run?

4. Can the Baron/Myerson truth telling model be used with multiple attributes?

D. SCOPE AND LIMITATIONS

This study examines the current acquisition reform initiatives and their emphasis on maximizing the gain for every dollar spent. It specifically addresses the need for mechanisms that can achieve the highest level of gain or utility by determining all of the key attributes that add benefit. Although many mechanisms have potential for this type of analysis, this thesis specifically examines the applicability of the Mark Johnson model. There are several points in the procurement process in which multi-attribute analysis employed via the Mark Johnson mechanism can be employed, however, many considerations must be made before acting on these suppositions. Specific imperatives for the successful implementation of the mechanism are also addressed.

The applicability of the Baron/Myerson model is examined due to its capability of achieving truthful information from contractors with its incentive compatibility structure. Due to the analyses performed in previous theses, this mechanism is not examined at length, but only in cursory form as it applies to the multiple attribute traits.

E. ORGANIZATION OF THE STUDY

Chapter II presents the background for current acquisition reform initiatives. It discusses the various mechanisms being developed to increase the caliber of the acquisition process and the work that has gone on before to utilize these mechanisms.

Chapter III examines multi-attribute models through the introduction of the Baron/Myerson model and the Mark Johnson model. The underlying principles of each model are discussed and then an example application of each is given with graphical representations of their implication via a contract award.

Chapter IV analyzes the applicability of the Mark Johnson model by examining four areas of potential usage. Under each area, an example is given with the accompanying pitfalls of utilization. It also details some of the implementation issues and concludes with a long range outlook.

Chapter V answers the research questions and presents the conclusions and recommendations. It also addresses areas of potential future research.

II. BACKGROUND

A. INTRODUCTION

Winston Churchill once stated "As it is, those who can win a war well can rarely make a good peace, and those who could make a good peace would never have won the war." [Ref. 2] As the conclusion of the Cold War is still being written into the history books, the United States is struggling with the transition into making peace. During war time, the old adage of sparing no expense in order to successfully accomplish the mission is commonplace. However, in settling into peace, the cost of national defense becomes ever more scrutinized.

Since the mid 1980's, the appropriations for defense procurement and other contracting venues have been drastically reduced. In order to continue to accomplish the mission, the inefficiencies associated with completing the task without regards to the cost must be curtailed. To this end, acquisition reform is being pushed from the White House down to the lowest levels of the Department of Defense.

By eliminating inefficiencies, it is assumed that the continuance of peace can be achieved at a reasonable price. The fallacy in this assumption becomes apparent when the drive for efficiency overcomes the requirement for effectiveness.

The successful implementors of a peace strategy must also consider the achievements that allowed for the success of their predecessors during war.

This chapter will present the background for the current acquisition reform initiatives. It will discuss the ongoing efforts to develop useful mechanisms for increasing the caliber of the acquisition process and the implementation of some of these mechanisms.

B. ACQUISITION REFORM INITIATIVES

On October 13, 1994, President Clinton signed into law the Federal Acquisition Streamlining Act (FASA) of 1994. The goal of FASA is to speed up and modernize the acquisition process by removing some of the burdensome requirements. Three features of FASA are likely to have major impacts on the acquisition process. [Ref. 3]

1. Simplified Acquisition Threshold

All acquisitions that are less than $100,000 now have special status in that the degree of oversight required is greatly diminished. This will affect over 90% of the DOD contracts [Ref. 3]. By making many laws inapplicable to contracts in this range and simplifying the acquisition procedures, real benefits can be gained.

2. Commercial Items

FASA broadened the definition of commercial items, allowing for more rapid procurement from commercial vendors at lower costs. This will allow for the purchase of off-the-shelf items without rigorous governmental inspection and testing requirements.

3. Truth in Negotiations Act

From its inception, there has been a prediction that the Truth in Negotiations Act (TINA) would increase administrative costs. Recent studies have confirmed this. One study estimates that the entire regulatory system adds 10 to 50 percent to the cost of doing business with the government [Ref. 4]. The new rules set forth in FASA will limit the necessity of TINA and will rationalize the need for its incorporation.

C. MAINTAINING THE PUBLIC TRUST

The entire acquisition process, including contracting methods, procurement, major weapon systems, etc. include a plethora of regulations that dictate what the government can and cannot do and what the contractor shall and shall not do. The FASA should alleviate many of these requirements, however, due to the nature of federal procurement, some must still stand.

1. Waste, Fraud and Abuse

When the costs to track and maintain the integrity of a system exceeds the cost of the system, the public outcry regarding waste, fraud, and abuse is understandable. However the very nature of spending public funds dictates the need for increased regulation in order to minimize the risk of fraud. Here the tradeoff between the waste incurred by excessive regulations must be weighed with the possibility/probability of the loss due to fraud. Peter DeMayo, vice president for contract policy at Lockheed Martin Corporation said that

> The system is `overloaded' with mechanisms aimed at preventing fraud, waste, and abuse. There is little time or incentive to be innovative or to exercise judgment. It is understandable that few are willing to exercise flexibility at the risk of shortening their careers. [Ref. 5]

Regulatory requirements that stymy innovation in the name of public interest are self-serving at best.

2. Source Selection

Due to the risk averse nature of DOD in some critical areas, awarding a contract based solely on the lowest price is not always a prudent decision. When the need for successful completion of the project is the overriding concern, source selection is often used. Source selection allows the government to select firms that have established themselves and have some minimum of proven technical expertise. However, an adequate number of firms must be selected in order to maintain competition in accordance with the Competition in Contracting Act [Ref. 6].

An area that uses source selection exclusively is contracting for professional services. This applies specifically to the Naval Facilities Engineering Command (NAVFAC) in its award of design contracts to Architect and Engineering firms. These contracts are considered critical because of the impact the designs created by them can have on the cost of the final construction project. Although the cost of the design effort is limited to 6 percent of the overall project cost, problems resulting from their deficiencies can boost the total project cost ten times or can even result in the inability to complete the project at all. To minimize this risk, the Brooks Architect and Engineer Act was established stating

> The Congress hereby declares it to be the policy of the Federal Government to publicly announce all requirements for Architect and Engineering services, and to negotiate contracts for Architect and Engineering services on the basis of demonstrated competence and qualification for the type of professional services required and at a fair and reasonable price. [Ref. 7]

The purpose of this act was to allow Architect and Engineering services contracts to be awarded based solely on technical expertise. Price was to be considered a secondary aspect, negotiated only after the "best" firm had been selected. It was assumed that this would eliminate the risk of poor performance and thereby decrease the overall risk to the DOD.

D. DOD'S IMPLEMENTATION OF FASA

Although the implications of FASA are still being resolved, the DOD has not sat back on its laurels waiting for direction. In fact, the DOD has taken FASA one step further. Secretary of Defense Perry signed a directive eliminating military specifications and standards and mandated the use of performance based specifications. This is in stark contrast to the old acquisition system.

1. Performance Based Service Contracts

Over $100 billion per year is spent by the federal government for service contracts. The Agencies' Service Contracting Practices Summary Report of January 1994 found government-wide problems regarding contractual statements of work, contract administration and cost effectiveness in these programs. For this reason, the Office of Management and Budget asked all federal agencies to:

- Make a formal endorsement of performance-based service contracting as the preferred methodology for acquiring services by contract
- Make a voluntary pledge to convert self-selected service contracts (preferably recurring) to performance-based
- Establish a high-level, agency wide task force to develop and manage the implementation of performance-based service contracting

- Select a senior level point of contact who will represent the agency on performance-based contracting matters [Ref. 8]

NAVFAC recognized the benefits of performance-based service contracting as early as 1980. They spearheaded several initiatives including the development of guide performance work statements and standard training courses for writing performance work statements and quality assurance plans. The requirement for a Schedule of Deductions along with the quality assurance plan has proven to be an equitable and effective means for enhancing contractor performance.

NAVFAC's experience in this field is being transferred throughout the federal government through briefings presented to representatives of 26 federal agencies. The overriding goal of this commitment is to achieve quality performance through efficient means. They are not only looking at decreasing the amount of money they spend for service contracting, but also looking to increase the amount of performance they get out of the contractors.

2. Shifting Towards Quality

While austerity is driving the need for efficiency, the demand for quality is also escalating. Several studies have been done on the tradeoffs of increasing quality. Bensen and Terasawa examined the effects of performance incentives in the two stage major system acquisition process. By dividing expenditures into the two distinct categories of Research and Development (R&D) and Production, and incentivizing each phase, alternate reimbursement schedules were created. Increased expenditures on R&D in the first phase could both increase performance in the first phase and reduce production costs in the second phase. Their model found that by including a term corresponding to the government's share of cost overruns, the tendency for systems to exceed performance minimums but result in cost overruns could be demonstrated. [Ref. 9]

When competition is introduced in the second phase, and the demand curve is altered by reducing the quantity demanded more than is justified in response to higher prices, it was found that the competing firms would report their costs more truthfully. This revelation would result in a greater surplus to the government and hence a higher utility.

E. ACHIEVING EFFECTIVENESS

Increasing efficiency is required in a downsizing environment. However, the goal should also be to achieve the mission. In order to accomplish the mission, the correct tools must be available. The correctness of those tools can only be determined through analyzing the effectiveness of the various systems throughout the DOD. The military could have extremely cost efficient weapons in the arsenal that are so archaic or of such low quality that they cannot fulfill the mission. To be able to analyze the effectiveness, all of the attributes that make up the effectiveness of the item must be considered. Many feel that this means that price should not be considered. This should not be the case. Price can be considered an attribute in the makeup of the good. All of the attributes including price, quality, reliability, timeliness, quantity, etc. should be considered.

F. EVALUATING MULTIPLE ATTRIBUTES

In the Bensen/Terasawa model, they were dealing with quality, price and quantity, evaluating the tradeoffs between these multiple attributes. Mechanisms for maximizing the benefit from these attributes is the basis of multiple attribute analysis.

1. Markov Analysis

A basic implementation of this analysis can be found in Markov Analysis. This analysis is based on probabilistic occurrence of each action. All combinations of possible outcomes are first ascertained and then their probability of occurrence are determined. The attributes that do not have distinct values but are instead continuous (such as quality), need to be broken into discrete values in order to employ this mechanism. By establishing thresholds, these attributes can be broken into distinct ranges and thereby used in this type of analysis. The goal of using Markov Analysis is to maximize the expected gain. This gain is found by multiplying the benefit of each the possible combinations by their probability of occurrence and summing them. [Ref. 10]

2. Baron/Myerson

Following heavily in this vain is the work done by David Baron and Roger Myerson. Their work centered around regulating a monopolist with the goal being to receive the highest expected gain from the producer. This gain was achieved by regulating a utility company or entity that has a natural monopoly. In these cases, a monopolist would set their prices to achieve a maximum profit. As long as the regulators do not know the actual costs, price setting will generally occur. When the actual costs are readily available, the regulator can ascertain a fair profit, but receiving truthful costs is unlikely due to the disincentives of firms to provide that information. To increase the consumers expected gain, Baron and Myerson altered the demand curve and paid the contractor based on this altered demand curve and the consumer surplus it generated. This achieved incentive compatibility because the contractor received the most profit when his actual costs were used in the new demand function. By reporting higher or lower costs, the quantity demanded and the surplus paid would result in a lower profit level. When the consumer is the government, such as when the government is forced into a sole source arrangement, this mechanism can be employed to maximize the government's expected gain. [Ref. 11]

David Bearden applied the Baron/Myerson model to government procurement in determining whether it could be used as a price regulating tool under a price-based procurement process. His findings were that the model could be of use in monopolistic situations as long as the government's demand curve was actually flexible. [Ref. 12]

3. Mark Johnson

In order to accomplish both efficiency and effectiveness, it is crucial that the government tell the contractor what they are really trying to purchase and why, as opposed to specifying how everything is to be done and not allowing the contractor the flexibility to optimize on what is desired. Mark Johnson realized the nonoptimality of this and developed a model that was both incentive compatible and allowed for the efficient allocation of resources in order to achieve the maximum benefit as derived from the key elements. [Ref. 1]

His work was based on the idea that key attributes could be identified and the relationship amongst them could be determined. By indicating these key attributes and their relationship to the contractor, the risk of spending time, money, and effort on items that are not optimally adding benefit to the government can be minimized. If the government looks strictly at price, as is often the case, then the contractor will give the bare minimum in all of the other areas because they add cost to the contractor, but do not give him any corresponding benefit from those additions. The bare minimum is generally specified; however, what is not specified is the tradeoff of an increase in any of those items beyond the minimum. Specifying minimums and maximums is often necessary, but having no incentive to go beyond these often results in a non-optimized solution.

Mark Johnson found that by publishing a utility function based on the government's expected benefits and allowing the contractor the flexibility to maximize this utility, the overall utility to the government is increased.

G. CONCLUSION

Proper implementation of FASA should give the acquisition process the much needed transfiguration it needs. Looking beyond this requires the foresight to understand that in this time of relative peace, effectiveness can not give way entirely to efficiency. Only by having an optimal balance of these two attributes can the military continue to function in maintaining the peace as well as preparing for the next conflict. The only way to truly optimize effectiveness is to identify the key attributes that give benefit and maintain flexibility in these attributes in order to maximize their combination. To address the issue of achieving effectiveness, multi-attribute models that have been developed for this purpose will be examined.

III. MULTI-ATTRIBUTE MODELS

A. INTRODUCTION

Several models have been developed recently attempting to achieve maximization of the utility or benefit gained when multiple attributes are considered key to the success of a contract or program.

Baron and Myerson did extensive work at maximizing the total social welfare generated when a monopolist exists in an asymmetric information environment. Their work concentrated on the sole attributes of price and quantity, but serves as a starting point for analyzing utilities generated by these two attributes.

Mark Johnson developed an economic model for maximizing the overall utility of a buyer even when the exact costs are unknown to the purchaser. His model is more encompassing and can be applied with a plethora of key attributes.

This chapter explains the origin and underlying principles of each model. It shows the advantages of the models given certain criteria. Finally, it concludes with an example of the application of each model via a contract award.

B. THE BARON-MYERSON MODEL

Baron and Myerson constructed an economic model for regulating the prices of monopolists. The overall objective of this model was to maximize the total surplus generated thereby increasing social welfare. This model also has potential use for maximizing the government's expected gain when multiple attributes are considered. This mechanism uses only price and quantity as the key attributes, but can be quite useful in achieving maximum gain or utility to the government in areas with little or no competition. The key to the model is the alteration of the government's purchasing plan based on the costs claimed by the contractor.

1. The Contractor's Motivation

Within the Baron-Myerson framework, the government's goal is to achieve truth-telling from the contractor in order to minimize the deadweight loss associated with normal monopolistic practices. In order to achieve this truth-telling, the Government pays all of the contractor's reported costs and gives a bonus of consumer surplus between the cost and the altered demand function. The contractor is enticed into telling the truth about his costs because he will maximize his total profit when he does. By reporting a lower than actual cost, he will be required to produce some items at a loss, decreasing his profits. By reporting higher than actual costs, he will be losing some of his possible profit because not as many units will be ordered. Only by telling the truth can he maximize his total profit.

2. The Government's Motivation

By receiving truthful information from the contractor, the government can adapt its schedule to maximize the utility gained by the government from the combination of the attributes of quantity and price. The form the revised demand function takes depends largely on the relationship between these two attributes and on the expected probability of distribution of the contractor's costs. By providing a more elastic demand function to the contractor, the government can maximize its expected gain and ideally its expected utility.

3. Determining the Revised Demand Function

Although many variations of the distribution of costs are possible, previous research has shown that no single assumption for distribution gives a dominant strategy. Therefore, as an example for later comparison, a Uniform probability distribution of possible costs will be used.

This implies that the government believes that any cost is equally likely. The government would then choose the lower and upper cost values based on its estimates, and create an effective demand curve that will maximize the government's expected gain.

C. THE MARK JOHNSON MODEL

Mark Johnson developed an economic model for maximizing the overall utility of a buyer even when the exact costs are unknown to the purchaser. The objective of the purchaser (Government) using the Mark Johnson model is to maximize the total utility gained from the purchase by using a function of the key elements that derive benefit to the government. These key elements can be anything ranging from quality to design features to timeliness to price. By defining the relationship between these key elements, the government allows the contractor to maximize his well-being (profit) while also maximizing the government's utility. This idealistic goal congruence yields incentive compatibility which is a necessary trait in efficient government contracting.

The model assumes that there are definable attributes other than price that yield benefit to the government and that a relationship between these attributes can be specified by the government.

1. Origin of the Model

Several authors have analyzed the tradeoffs inherent in multidimensional bidding mechanisms. Their common links have been the information asymmetry between a buyer and the potential suppliers. While the buyer generally knows what he wants, he does not know what the sellers are capable of, and the sellers, though knowledgeable of their own capabilities, have varying degrees of understanding of what the buyer wants. This differs from the standard auction framework. Because of this, standard bidding procedures designed to operate in the one-dimensional environment (that of price) do not operate efficiently in this more complex setting.

Mark Johnson realized that most of the work done in this area was in detailing the failings of the existing bidding procedures (auctions) in these more complex situations. He decided instead to focus on the design of bidding mechanisms that retained their desirable properties even in the complex multidimensional setting.

In his research, he found that incentive compatibility was key to realizing an efficient outcome. He also realized that giving the contractor flexibility in those dimensions would allow the contractor to maximize his output with the minimum of effort, thereby creating the greatest gain for both parties by telling the truth.

2. Principles of the Model

One of the problems with any contractual system is receiving accurate bids from the potential contractors. As contractors conduct their business on the premise that they will receive profits, it is not uncommon for hedging to occur in order to maximize those profits. In order for the government to receive the best possible utility out of the contract, it is not necessary for the government to know all of the contractors' opportunity costs, or even the tradeoff costs for the key attributes. It is, however, necessary for the contractors to be truthful in their bidding of what they can actually provide. To that end, the Mark Johnson mechanism incorporates a Second Sealed Bid Auction (SSBA), commonly referred to as a Vickrey Auction.

The Vickrey Auction consists of two stages, that of bidding and of awarding. The format is that the government announces a multidimensional evaluation function (a quantitative function based on the key attributes) that establishes the "value" of each of those attributes to the government. The contractors then bid on the contract giving their "best" value derived by that function, with the high-value firm being awarded the contract. The award, however, is based on the value submitted by the second highest bidder, thereby achieving truthful bidding from the contractors.

The contractors will be truthful in their bidding, because over or underbidding their actual utility will not benefit them. An example may prove useful in demonstrating this phenomenon.

3. Example of Vickrey Auction for Truth Telling

To simplify this example, we will assume that there are only two contractors. Given that each contractor has a choice between 1) telling the truth, 2) overbidding and 3) underbidding, we will examine the impacts of each to determine what will be in the contractor's best interest. For each of these possibilities, the competing contractor can also tell the truth, overbid, or underbid. In this example, it will be assumed that the actual maximum utility attainable for contractor I is 100 while that for contractor II is 90.

Table 3-1 shows the possible outcomes of the auction under the nine possible scenarios.

II \ I	Tells Truth Utility = 100	Underbids Utility = 85	Overbids Utility = 115
Tells Truth Utility = 90	+10 0	0 +5	+10 0
Underbids Utility = 75	+25 0	+25 0	+25 0
Overbids Utility = 105	0 -10	0 +5	-5 0

Table 3-1. Net Utility Gain as a Function of Differing Strategies

The table shows the added utility gained (or lost) through the strategy employed by each of the two contractors. As an example, the cell Tells Truth/Tells Truth indicates that if this strategy was employed by both contractors, then contractor I would have an added utility of 10 (the contractor only has to provide a utility of 90, however, he can produce up to 100 and still maintatin his profit reservation level). Contractor II would have an added utility of 0 because he would not be awarded the contract.

As can be seen, a dominant strategy does exist for contractor I, that of telling the truth (with contractor I's utility gains being indicated by shadowing). By overbidding, contractor I will be awarded the contract, however there is a possibility that he will be required to provide a utility beyond his capability. This would occur in the cell Overbid/Overbid and would result in a loss of 5 in utility (contractor I must provide a utility of 105, however he is only capable of producing a utility of 100 given his profit reservation level, therefore he must lose profit in order to come up with the additional utility). By underbidding, contractor I will not be awarded the contract when contractor II tells the truth.

Contractor II also has a dominant strategy in telling the truth (with contractor II's utility gains being indicated by shadowing). Underbidding would not allow him to be awarded the contract, and overbidding may require that he perform beyond his capability. This would occur in the cell Tells Truth/Overbid and would result in a loss of 10 in utility (contractor II must provide a utility of 100, however he is only capable of producing a utility of 90 given his profit reservation level, therefore he must lose profit in order to come up with the additional utility). There is the chance that while overbidding, contractor II may still be awarded the contract at a level he can perform, however, he would also have been awarded the contract had he told the truth about his abilities. Therefore, the dominant strategy of truth-telling exists for both contractors.

Thus, the SSBA entices the contractors to tell the truth about the utility they can generate for the government. To better understand the application of the utility function and how it differs from the standard award mechanisms and the method in which a contractor will derive his bid, an example of a simple award will be given.

D. AWARDING A CONTRACT

To give meaning to the terms defined earlier, an example of the application of both of the models will be given to demonstrate their characteristics in a qualitative sense. Both examples will assume that a contract will be awarded for the delivery of some goods. The Baron/Myerson example will be applied to goods with a flexible quantity and a monopolistic type of contractor base. The Mark Johnson example will be applied to goods with a flexible delivery date with competitive contractors.

1. Under the Baron/Myerson Model

For this example, the following assumptions will be made:

The government Demand = 600 - 10P (P is price per unit)

Minimum expected cost = $5.00 per unit

Contractor I's actual marginal cost = \$10.00 per unit

Using these assumptions, the Baron/Myerson model would yield a revised demand curve of Demand = 660 - 22P from P = 5 to 30 and Demand = 600 - 10P with P < 5 (an unexpected value). Given that the contractor wants to maximize his profit, he would realize that by announcing a cost of \$10.00 (his true cost), he would achieve that maximization as shown in Figure 3-1. At an announced cost of \$10.00 the contract award would be made for a quantity of 440 units being produced at a price to the government of the contractor's actual costs (440*10 = \$4400) plus a bonus of the consumer surplus generated by the revised demand curve (20 * 440 * ½ = \$4400) for a total of \$8800 as shown in Figure 3-2. Thus the bonus or cost of getting the contractor to tell the truth was \$4400. Although this may seem excessive, the government's gain which is equal to the consumers surplus under the original demand curve minus the surplus paid to the contractor would be \$7920 (½ * (50 + 6) * 440 - 4400). This is noticeably higher than the \$3125 (½ * 25 * 250) gain achieved by the government when the contractor acts as a monopolist without a truth-telling mechanism.

2. Under the Mark Johnson Model

Although all government acquisitions have many attributes which add to their utility, for simplicity only the attributes

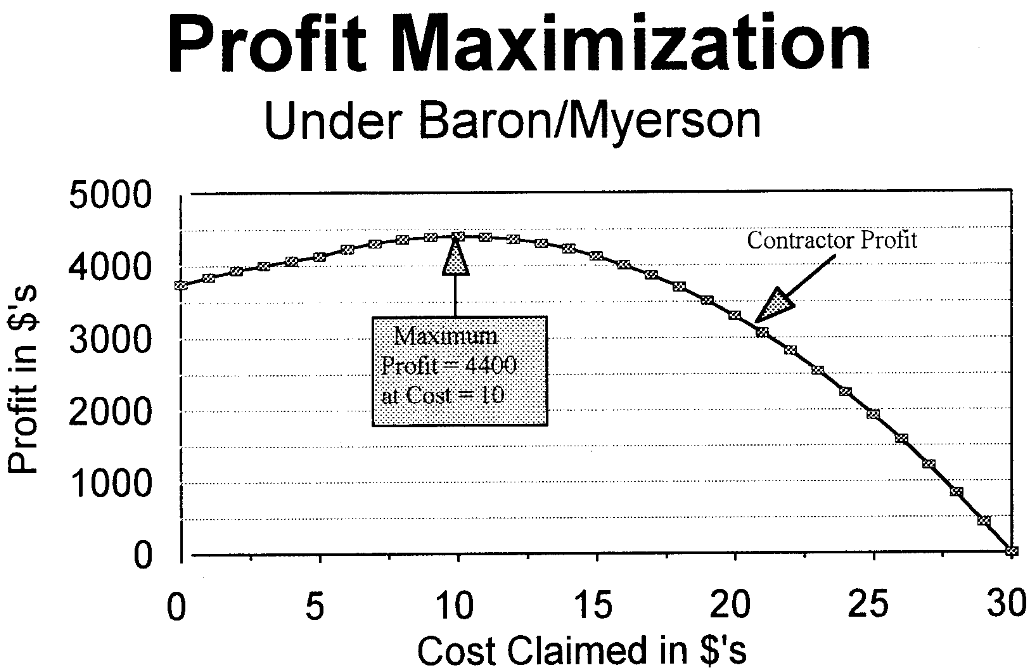

Figure 3-1

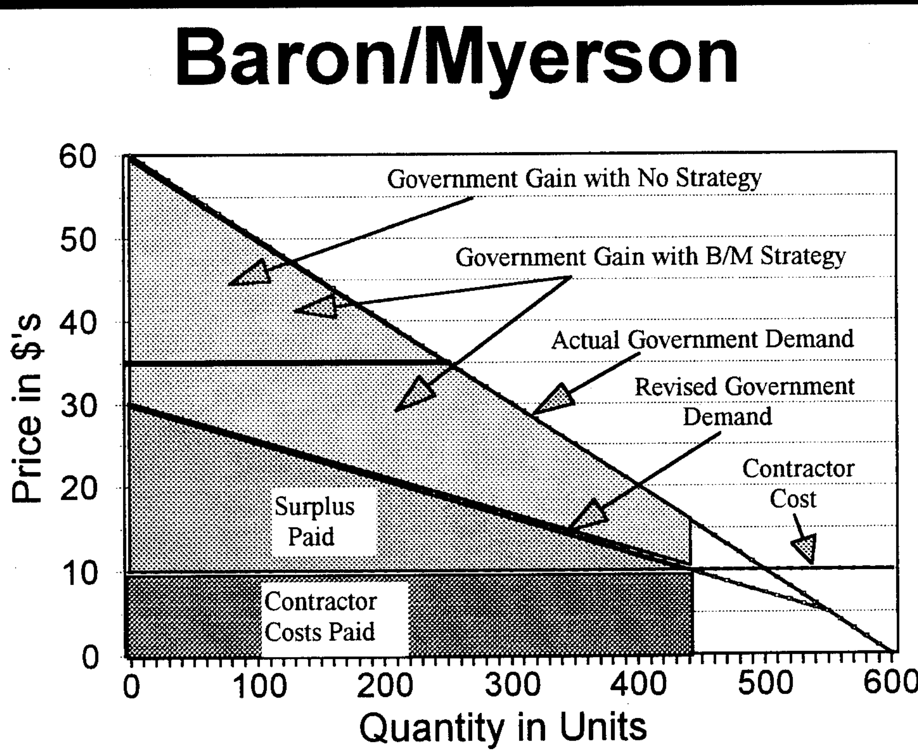

Figure 3-2

of price and timeliness of delivery will be considered. If the contractor's sole compensation is monetary, then he will produce at the timeliness most convenient for himself, and will not take the government's utility of that timeliness into consideration. If maximum allowable times are stated, then the contractor will most likely deliver at that maximum allowable time.

In this example the government's utility function, the government's demand function, the contractor's profit functions and the contractor's reservation levels for profit will all be treated as given. It will then be shown what will happen using a naive contracting approach of no strategy versus employing the Mark Johnson mechanism. Given that:

Government utility function is $U = (60 - P) * (91 - T)$

(where P is price per unit and T is time in days)

Maximum allowable delivery time is within 90 days

Contractor I Profit = $(P - 30) + (T - 50)$

Reservation level of Profit = \$50 (minimum profit)

Contractor II Profit = $(P - 40) * (T - 30)$

Reservation level of Profit = \$100 (minimum profit)

The contractor's profit functions are based on their technology levels and differ due to their expertise or experience in the specific contracting areas. Their reservations levels for profit depend on the various opportunity costs they face at the time of the contract.

Under the naive approach, assuming that there is sufficient competition to force the contractors to go for their minimum profit reservation levels, we find that both contractors will take the maximum time allowed as stated earlier, which in this case is 90 days. Solving each equation for P given the profit reservation levels results in contractor I bidding a price of $40 (P = 50 + 30 - 90 + 50) and contractor II bidding a price of $41.67 (P = 100/(90 - 30) + 40). In this case, contractor I will be awarded the contract at a price of $40 giving a utility of 20 ((60 - 40)*(91 - 90)) to the government. This of course assumes that the contractors are absolutely truthful in their reporting of actual costs and is a "best case" scenario with regards to the naive contracting approach.

Using the Mark Johnson mechanism, we first need to determine what each contractor will bid. Because the second-price type auction is being used, we see that each contractor will tell the truth about his anticipated costs, so each will determine the maximum utility they can bid while still achieving their profit reservation levels.

To accomplish this, the objective function of contractor I would be:

$$\text{Max } U = (60 - P) * (91 - T)$$

$$\text{s.t. } (P - 30) + (T - 50) = 50$$

Solving this graphically in Figure 3-3 yields U = 110 with P = \$50, T = 80.

The objective function of contractor II would be:

$$\text{Max } U = (60 - P) * (91 - T)$$

$$\text{s.t. } (P - 40) * (T - 30) = 100$$

Solving this graphically in Figure 3-3 yields U = 621 with P = \$45.90, T = 47.

By this example, contractor II would be awarded the contract because of his higher utility bid of 621. The contractor would, however only be required to provide the utility bid by the second highest bidder, or 110. Contractor I would then calculate the time and price given this utility that would gain him the maximum profit. This would result in:

$$\text{Max Profit} = (P - 40) * (T - 30)$$

$$\text{s.t. } (60 - P) * (91 - T) = 110$$

Solving this graphically in Figure 3-4 yields Profit = \$597 with P = \$53.90 and T = 73.

Thus the overall gain to the government is the increase in utility from 20 under the naive approach to 110 under the Mark Johnson mechanism.

By this we found that the contractor would charge a price of \$53.90 and deliver the goods in 73 days. Although this is

$13.90 higher than the price under the naive approach, it also gives a 17 day quicker delivery, resulting in the higher utility. Even though the "best case" scenario was considered for the naive approach, and the contractor received much more than his reservation level of profit ($597 vs $100), the government still had a noticeable gain in utility.

In this example, the advantage of the Mark Johnson mechanism is clear, but under what circumstances could it actually be applied?

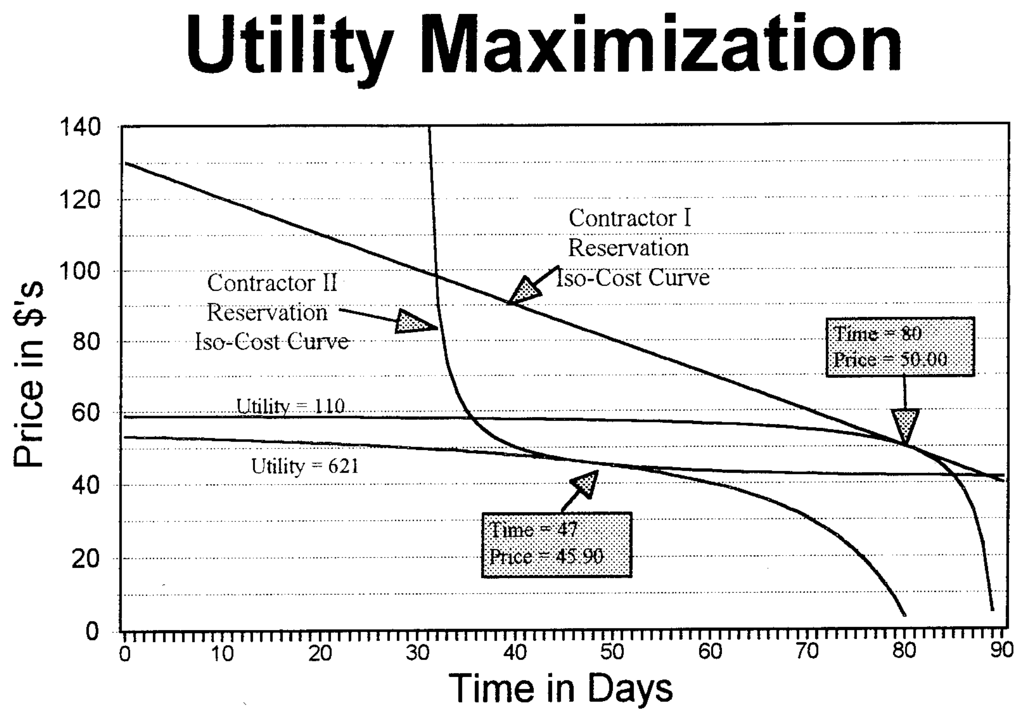

Figure 3-3

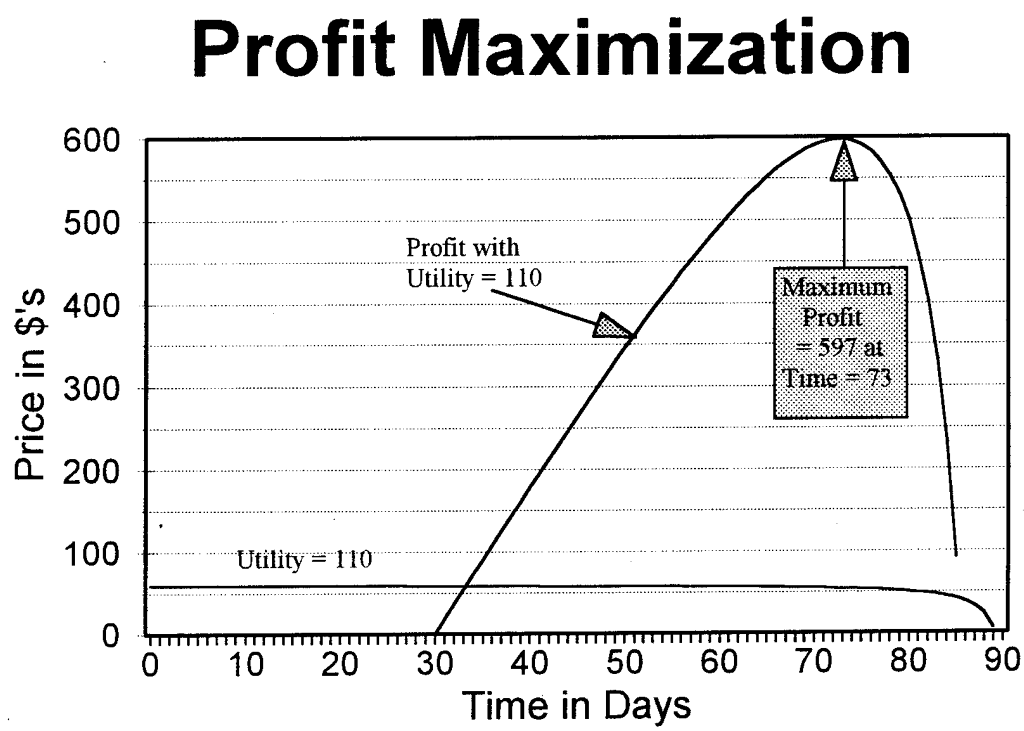

Figure 3-4

IV. IMPLICATIONS OF USING THE MODELS IN DOD PROCUREMENT

A. INTRODUCTION

This chapter will analyze the areas of potential use for the multi-attribute analysis mechanisms, specifically addressing the usefulness of the Mark Johnson variation as applied to source selection, contract award, contract modifications and finally to cost effectiveness improvements. The imperatives necessary for successful execution of these mechanisms and some short and long range implementation issues will also be analyzed.

B. POTENTIAL USES OF THE MARK JOHNSON MODEL IN DOD CONTRACTING

The Mark Johnson mechanism has its strength in the fact that the marginal tradeoffs between key attributes are set equal at the optimal solution by both the government and the contractor. This marginalism results in the most efficient solution. This is not to say that this mechanism is a panacea for the contracting world. In the areas in which it has its strengths, it is one of the best, however, it does have certain limitations that must also be addressed. The following four subsections will analyze several areas in which the mechanism can be employed.

1. Contract Award

As shown in Chapter III, an award based on the Mark Johnson mechanism is plausible and would be prudent in certain circumstances. There are, however, several factors that are paramount to the successful implementation of this mechanism.

a. Effective Competition

When there is not much competition, or when there is a contractor that has an extreme technological advantage in one or more key attributes due to economies of scale or technical expertise, this mechanism is not efficient due to the Vickrey Auction aspect. By allowing the contractor to produce at the second highest bidder's utility value, the government may give away more than they gain. In these type of situations, a mechanism such as the Baron/Myerson mechanism could be much more beneficial in maximizing the government's expected gain.

b. Government Estimates

In order to effectively use this mechanism, government estimates for its own utility would need to be made. Once determined, these benefits should be made public. If the benefit added by certain attributes is vague, then the added utility of those attributes should remain vague.

The government estimate would then serve as a starting point for developing the utility function. The government estimate could serve as a set utility of say 100. From this, indifference curves could be developed by determining the value of trading off each attribute. For example, if the government estimate is $100K and 90 days, the value associated with a completion of 80 days could be estimated at $105K. By continuing this tradeoff analysis, parallel indifference curves could be superimposed and used to develop the actual utility functions. Obviously this gets much more complicated as more attributes are added. Graphical analysis would fail with more than three attributes, but a mathematical representation could still be developed.

c. *Determining the Utility Function*

The government must be able to determine a quantitative utility function that adequately describes the tradeoffs between the key attributes.

Before the utility function can even be developed, the government must determine what attributes are key to the contract. An obvious starting point is always price because it is the easiest to quantify. It also has controlling factors due to budget constraints. Other items that could be considered are time (or timeliness), quality, reliability and quantity. Of these, only time is an easily quantifiable item, as demonstrated in the example. Quality and reliability are both after-the-fact attributes. These both give high risk to the contractor due to the uncertainty inherent in them. By quantifying these items, the contractor's payment and hence his profit will be undetermined until the time these attributes are tested. This would give incentive to the contractor to perform his own testing and modifications until his marginal cost of testing was equal to the marginal increase in payment. Again this is an efficient solution. By increasing the contractor's incentive to increase reliability and quality, innovation and efficiency will be motivated.

In most attributes there is a minimum acceptable value (quality, reliability and quantity) and for some there may be maximum acceptable values (price and time). Due to budgetary constraints, the price will usually have a ceiling. Although the tendency to lower the ceiling to the original government estimate might exist, it is not recommended. By lowering the ceiling, the most likely result would be an end point solution given by the contractor. If the government had set a maximum price of $45.00 in the Mark Johnson example in Chapter III, then the contractors would have bid 85 days and 50 days respectively, giving a utility of 90 and 615 respectively to the government. This end point solution clearly is inferior because the new utility award level would be at 90, whereas a utility of 110 was achieved without a ceiling. Even with the ceiling imposed, the Mark Johnson mechanism was efficient in that the highest possible utility was achieved given the budgetary constraint, however, a relaxed budgetary constraint could have resulted in an even higher utility.

Minimum acceptable values for attributes such as quality could also result in an end point solution if set too low. This is not to say that minimums and maximums should not be set. At times they are required by statute or by mission requirements. Truly effective utility functions could factor minimum and maximum values into the utility functions, such as the term (91 - T) in the example. If time goes over 90 days, then this term is no longer positive. A requirement that each term be positive could be included with the function which would effectively set the maximum allowable time without having to also specify a ceiling.

Determining realistic tradeoffs between the key attributes will prove to be the greatest challenge in specifying a utility function. The signals sent through these tradeoffs should ideally align the contractor to the government's thinking on the desirability of certain traits. Overemphasizing certain criteria could, however, result in an efficient, but ineffectual contract award.

d. Government Believability

The success of this mechanism would depend largely on the believability of the government by the contractors. Deviating from the agreed-on award mechanism or posted utility function would foster discontent and would very likely lead to deflated utility bids or even the withdrawal of some contractors from the bidding pool.

e. Degree of Risk

As was stated in Chapter II, the Truth in Negotiations Act specifies that the contractor is supposed to tell the truth regarding costs and pricing data. But when there is uncertainty facing the contractor about the actual costs or tradeoff values because only projections are being used, the TINA becomes an ineffectual tool. By increasing the risk the contractor faces, he will generally become conservative regarding what he can actually perform. In an attempt to both get the maximum performance and the minimum payment, the government is putting the contractor in a very tenuous situation. Therefore, the more certain a contractor is regarding his tradeoff values, the more truthful he can be and is expected to be.

f. Penalties for Nonperformance

Although it may seem that the government should then back down on their demands in order to alleviate some of the risk to the contractor, this would be counterproductive to the process. The contractors must be forced to abide by their bids in order for credibility to be formed. In the example in Chapter III, if the goods were delivered in 81 days then the contractor would only be paid $49.00, regardless of his percentage completion at the originally agreed upon 73 days. This is due to the requirement to still yield a utility of 110. Therefore, the penalty incurred by the contractor would be equal to the lost utility by the government. This marginal approach is much more efficient than the presently used liquidated damages clause in construction contracts because the government actually gets the "true" liquidated damages amount based on their calculated utility function vis-á-vis receiving a set dollar amount per day regardless of the number of days.

Thus with these imperatives addressed, the Mark Johnson mechanism could be employed in a contract award. Another area with potential usage of a variation of the mechanism is in the realm of source selection.

2. Source Selection

In many circumstances it is desirable to selectively pick the source for fulfilling a contract. One such example is in the area of professional services contracts. NAVFAC uses a source selection process to select the professional services of Architect and Engineering firms for developing designs for new construction projects. The attributes involved in this selection process make this an ideal candidate for the use of a multi-attribute model.

a. The Solicitation

The Brooks Architect and Engineer Act of 1972 stated that Architect and Engineering services were to be awarded based on demonstrated competence and qualification for the required services at fair and reasonable prices. When the need for a new construction project is first conceived and initial technical data gathered, a synopsis of the proposed project is posted in the Commerce Business Daily, detailing the 5 to 7 criteria or critical elements considered necessary for a qualifying firm to possess in order to successfully complete the project. These criteria are the key attributes that will be used to determine the most qualified contractor. The most qualified firm is required to be awarded the contract as long as fair and reasonable prices can be negotiated.

The synopsis lists a description of the project to be undertaken as well as an anticipated price range for the project. Also listed is the criteria on which the contractors will be evaluated to determine the most qualified firm. These criteria are generally listed in the order of importance to the government. Among common criteria or critical elements used are:

- Recent specialized experience
- Professional qualifications of the staff
- Ability to complete project within time constraints
- Past performance on related contracts
- Geographic location
- Volume of DoD work recently completed

b. The Slating Process

For many years NAVFAC promoted a two-stage process for the selection of the contractor to whom the award would be made. The first stage was the weeding-out phase, in which the field of potential contractors would be narrowed to 3, as per the 1972 Act. The second phase would be the review of those contractors on the selected criteria. Once the "best" contractor was determined, detailed reports indicating the reasons why each of the unsuccessful bidders was not chosen would be given. Generally, the criteria are parsed through in order, dropping out contractors that are not qualified or are weak in the earlier or more important criteria. [Ref. 13]

This system seems to work, as there have been few protests. However, this is likely due to the subjective nature of these awards. It would be very hard for a company to prove they were better than another in any tangible way when the selection criteria are so vague. This flexibility does give the government an extreme advantage in that they can weed out contractors who are not easy to work with. If a contractor does protest, then they will most likely be shuffled to the bottom of the stack in the future. This threat not only keeps contractors from protesting, but also gives them big incentives to work with the contracting officer on their current contracts.

c. *Drawbacks of the Current System*

One problem of this system is the lack of consideration of price in the critical elements. The 1972 Act specifically states that the most qualified firm is to receive the award as long as a fair and reasonable price can be negotiated. Although this may be an effective way of determining the most qualified contractor without the influence of price, it is not efficient. The "fairness and reasonableness" of the price can not be determined in a competitive sense. A comparison of the price versus the government estimate may lend some credibility to its reasonableness, but only the market can truly make that determination. A much better approach to the reasonableness question would be to include price as one of the critical elements. By weighting it with the rest of the elements, it would not have overriding tendencies, but could ensure that the prices are reasonable.

Another problem with this system is also one of its greatest strengths. It is extremely subjective at all levels. The slating board can disagree on which contractor they think is the best overall and there is no way to rectify this situation. There are no concrete weighting criteria that specify the relative importance of each element because all of the elements are qualitative without any quantitative correspondence. By applying a variation of the Mark Johnson mechanism, some of the subjectivity can be removed by turning the qualitative reviews into quantitative ones.

d. Applying the Mark Johnson Mechanism

By developing a utility function from the key elements and a scoring range for each of those elements, the board can come up with a system for dealing with these differences in opinion. This utility function should be developed when the key elements are first determined and prior to the opening of the various contractors proposals.

The simplest form of utility function would have the factors equally weighted, thereby yielding a utility of the sum of each of the rated attributes. For most circumstances, this would not be sufficient because each attribute does not carry the same importance. For example, the distance a firm is away from the site of the project is usually not as important as the number of civil engineers to be dedicated to the project. There are also some elements that appear to be binary in nature, but have unstated ranges associated with them. By exceeding a certain minimum criteria, the firm will be considered, while the magnitude by which the firm exceeds the minimum has little differential effect. For example, if the criteria was that the firm must have at least 3 years experience, a firm with 20 years would be better than one with 5 or 10, but would be considered the same as one with 18 or 19 years. By contriving a point system based on ranges, this attribute could be easily incorporated without distorting the overall capabilities of a firm.

This demonstrates that variations of the Mark Johnson mechanism can be used in source selection to get the most qualified contractor at the most reasonable price. The next section will examine the application of the mechanism to contract modifications.

3. Modifications to Existing Contracts

When a modification to an existing contract is required, the contractor assigned the original contract is essentially getting a sole-source contract. Due to the lack of competition in this, the straight Mark Johnson mechanism would be of little use since its award structure is based on the second highest bidder. However, the utility function part of the mechanism can still be employed to give the contractor the flexibility to maximize the gain to the government. Obviously the government wants to get the additional work done for as little money as possible, but again money is not the only thing that adds benefit to the government.

An example of this would be a contractor doing a renovation of some barracks when an unforseen site condition is discovered, the existence of asbestos in some of the walls. This would require a modification to the contract in order for the asbestos to be removed and would generally also result in a time extension to the contract being given if it can be shown that this additional work would impact the critical path of completing the contract. Since most renovation projects have liquidated damages averaging about $1000 per day, the amount of the time extension can be critical to the contractor in maintaining an adequate profit level. But if the actual amount lost to the government will be less than $1000/day then it would be beneficial if they could somehow trade off some days for some additional work. If the contractor is running behind for whatever reason, he may be more than willing to trade some work for days. By establishing a utility function that sets the relationship between these values based on the government's estimate of how long it should take the contractor, and how much it should cost, the government can give the flexibility to the contractor. This added flexibility will allow the contractor to give the same utility to the government, while allowing him to maximize his benefit as well. Thus, the government can set a higher required utility than would normally be possible just by giving some flexibility to the contractor.

By using the utility maximizing aspect of the Mark Johnson mechanism and giving some flexibility to the contractor, the government can increase their utility received through contract modifications. The last area of potential use that will be analyzed is that of platform performance improvements.

4. Cost Effectiveness Improvements

Whenever improvements are considered for current aircraft, ships or other major weapons systems, all major subsystems that add to the improvement must be considered. These subsystems are similar to the key attributes in the previous analyses. Cost Effectiveness Improvement Programs are currently undertaken using multiple attribute analysis of the subsystems to achieve the best improvement package given a funding constraint.

To accomplish this, experts on each of the subsystems are gathered in order to get realistic information regarding the costs and improvement levels possible in each of these areas. At this time, a matrix is laid out containing one row for each of the subsystems, and one column for each of the possible improvement levels for each of these systems. Next, the relative importance of each of the subsystems is determined and a weighting factor (WF) is assigned and entered into the matrix. The experts then assign Benefit Values (BV) to each of the possible improvements of their subsystems with the baseline or status quo configuration having a BV of 0, the ultimate improvement having a BV of 100, and the intermediate improvements having BV's between the two.

The next step is to conduct cost analysis of each of the improvement levels for each subsystem. These values are then inserted into the matrix at their corresponding improvement levels. This effectively accomplishes a double weighting system between improvement areas and improvement levels.

Once the matrix has been completed, Benefit Points are calculated by multiplying the WF by the BV's and dividing by the cost for each cell. The cell giving the highest Benefit Points is the subsystem improvement that gives the highest marginal benefit for the least marginal cost. At this time, the "Optimal Pareto Frontier" is determined by first plotting the cost of this improvement with the benefit associated with it (determined by WF * BV). Subsequent steps on the optimal frontier are then plotted by taking the subsystem improvement with the next highest Benefit Points and plotting it's additional cost with it's additional benefit, thereby giving the cumulative cost and benefit derived.

Finally, the procedure is repeated for the subsystem improvements that give the least Benefit Points, thereby creating the envelope of possible improvements. At this time, the budgetary constraint can be plotted and the package of subsystem improvements within the budget that yield the highest benefit can be determined.

Table 4-1 demonstrates the application of this method with the Theater Ballistic Missile Defense Design Project. Figure 4-1 shows the "Optimal Pareto Frontier" and the envelope of possible packages along with the budgetary constraint of $625 for the project. Under that constraint, the optimal package is found to be:

- Level 1 improvement to Velocity for $50K
- Level 3 improvement to Payload for $150K
- Level 3 improvement to Guidance for $200K
- Level 2 improvement to Engagement for $100K
- Level 2 improvement to Reliability for $50K
- Level 2 improvement to Maintainability for $70K

These improvements cost a total of $620K and yield an improvement benefit of 82% of maximum. This compares favorably with the $1070K that would have been expended for the maximum (100%) improvement benefit of all subsystems.

The major contribution of this method is not simply in the mathematics, but from the insights gained through the processes of discussion and consensus building in constructing the matrix. The success of this technique can only be achieved through the presence of an impartial facilitator who can effectively lead the concerted effort of a group of "subject matter experts" to develop a realistic tradeoff analysis based on all of the background facts. This application is most applicable when there are major budgetary constraints and it is unclear if a reasonable solution is attainable.

The benefits of this type of decision process are:

- Provides a common yardstick to evaluate competing systems having dissimilar benefits
- Displays the relative overall cost and benefit of any one design compared to other designs
- Displays the variables and levels that comprise the best design for any given level of the overall resource expenditure
- Compares different designs proposed by the decision makers with more efficient designs, that either cost less and provide the same overall benefit, or provide more benefit for the same cost
- Group effort vice individual judgement

Sub-System	Weight Factor	Baseline	Level 1	Level 2	Level 3	Level 4
Velocity[1] Cost BV	80	$0 0	$50[7] 45	$100 60	$200 100	
Payload[2] Cost BV	100	$0 0	$20 40	$100[8] 60	$150 80	$250 100
Guidance[3] Cost BV	140	$0 0	$20 15	$40 40	$200[9] 100	
Engagement[4] Cost BV	160	$0 0	$50 30	$100[10] 80	$250 100	
Reliability[5] Cost BV	60	$0 0	$20 60	$50[11] 80	$100 100	
Maintain[6] Cost BV	60	$0 0	$40 60	$70[12] 100		

Table 4-1 Theater Ballistic Missile Defense Design Project after Reference 14

1. Velocity is in terms of Mach (times the speed of sound) with Baseline = 1.8, Lvl 1 = 2.0, Lvl 2 = 2.4, Lvl 3 = 2.8
2. Payload is in lbs with Baseline = 300, Lvl 1 = 500, Lvl 2 = 800, Lvl 3 = 1000, Lvl 4 = 1400
3. Guidance is radius to target in meters with Baseline = ±200, Lvl 1 = ±50, Lvl 2 = ±10, Lvl 3 = ±0
4. Cooperative Engagement is various add on systems to enhance remote operation with Baseline = None, Lvl 1 = Attack Warning, Lvl 2 = Near Real Time, Lvl 3 = Real Time
5. Reliability is mean time between failures measured in hours of flight with Baseline = 200, Lvl 1 = 400, Lvl 2 = 800, Lvl 3 = 1200
6. Maintainability is mean time to repair measured in minutes with Baseline = 60, Lvl 1 = 45, Lvl 2 = 30
7. This cell represents the level 1 improvement to velocity system with a speed of M2.0, a cost of $50K and Benefit Points of 45
8. This cell represents the level 3 improvement to the Payload with a payload of 1000lbs., a cost of $150K and Benefit Points of 80
9. This cell represents the level 3 improvement to the Guidance system with a radius of ±0m, a cost of $200k and Benefit Points of 100
10. This cell represents the level 2 improvement to the Cooperative Engagement system to Near Real Time, a cost of $100K and Benefit Points of 80
11. This cell represents the level 2 improvement of reliability to 800 flight hours between failures, a cost of $50K and Benefit Points of 80
12. This cell represents the level 2 improvement to the maintainability with a mean time to repair of 30 minutes, a cost of $70K and Benefit Points of 100

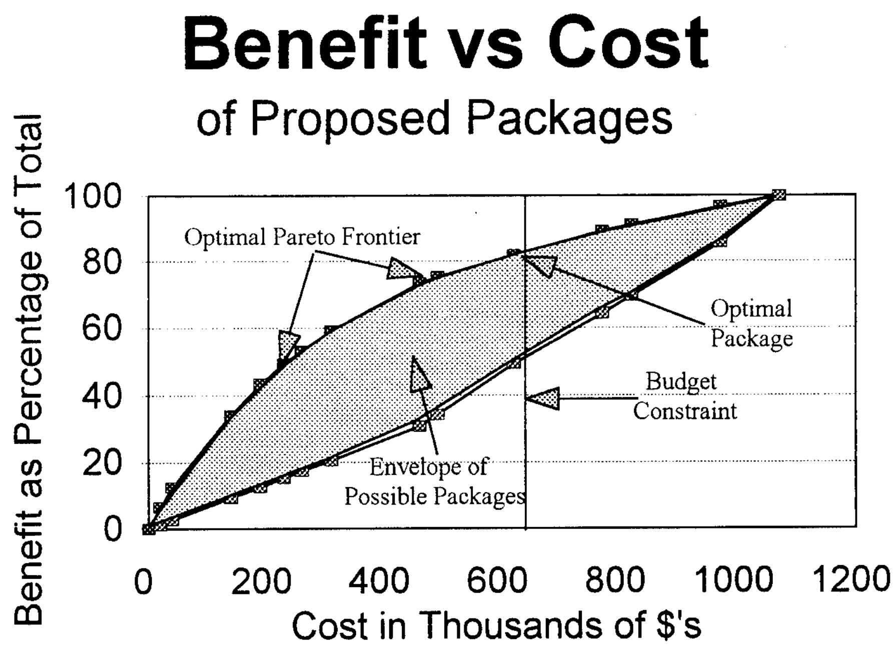

Figure 4-1

The largest weakness of this method of analysis is the fact that the costs associated with each improvement level for each subsystem are considered independent. This may be true in some areas, however, it is definitely not true in all areas. In the example, the increase in payload will very likely impact the cost to increase the velocity of the missile. The reliability of the missile will very likely effect its repairability. By not addressing this interdependence, the static costs established in the matrix will tend to be unrealistic and may lead to cost overruns and nonoptimal solutions.

Utilizing the utility function of the Mark Johnson mechanism would allow all of the tradeoffs to be incorporated. By using the experts to establish a utility function based on the subsystem improvements, a truly optimal solution can be found given the budget constraint. Because a multiple attribute mechanism is already being employed in this area, the transition to the use of the Mark Johnson mechanism might meet with little resistance.

The last four subsections analyzed areas in which the Mark Johnson mechanism could be used in government contracting. There are however, initial as well as long term obstacles that must be overcome in order to successfully implement this new technique.

C. IMPLEMENTATION ISSUES

As with any new system, there are costs associated with the transition into their use. For the implementation of this mechanism, there are both initial start up costs as well as long term costs.

1. Initial start up costs

There would be a large potential for increased Termination for Defaults on contracts awarded under this mechanism at the onset. This would be due to contractors not understanding the mechanism, or trying to game the system. To gain credibility, the government must stand by its decisions.

However, whenever a new mechanism is employed, there is a tendency to test whether the stated objectives are really what the government desires. By maintaining a strict minimum in allowable utility, there is a great possibility before the method is completely understood that contractors will not realize the magnitude of the financial impact of non-compliance. The current use of liquidated damages per day are easily calculated and their effects are understood. But the advent of liquidated damages being assessed by the actual decline in utility may leave the contractors perplexed.

Before the public completely understands the concept, there is potential for increased reports of waste, fraud and abuse. Since price will no longer be the one driving force, there will be times when the public sees that the government is paying more than it absolutely has to. The fact that extra is being paid, but for extra utility in the form of quality, reliability, timeliness, etc., may not be fully understood. As the public becomes aware of the new policy and sees the shift towards the way private industry already operates, this problem should go away.

2. Long Term Costs

As with any cost cutting scheme, there is a very real potential to reduce the number of contractors willing to perform defense contracts. If a firm cannot make at least its reservation level of profit then it will cease to be a going concern. This is obviously of great concern if the contractor cannot complete a contract already undertaken because of the long delay in reprocurement and the increased costs involved. It is also of concern in the long run because, as fewer contractors are willing to take on defense jobs, the reduced competition aspect will inevitably increase the price and decrease the utility the government will get. The fewer the contractors, the larger the gap between the highest and second highest bidder, which means the lower the ultimate benefit received. For this reason competition is desired, but the very nature of decreasing profits causes a reduction in competition. As has been stated earlier, the Vickrey Auction is not necessarily efficient in the face of reduced competition. Only if the remaining contractors are close in their abilities in the key attributes will they submit utility bids close together. The farther these bids are apart, the less the government gains through the use of this mechanism.

3. Other Issues

As with any new system, there is always a tremendous built-in bias towards the present system and any proposed deviation will inevitably meet with resistance. Because of this resistance, large scale use of this mechanism would not be prudent until an assorted base of contractors that both understand the system and believe the government can be established. Testing this mechanism on a small scale could demonstrate the actual benefits received by the government and gain valuable advocates.

D. SUMMARY

The best way to maximize the understanding between the contractor and the government is to be in constant contact with the suppliers. When the contractors know what the government is trying to accomplish and why, they often have value added exercises they can perform that cost them little or nothing but go a long way in increasing the government's utility. Whenever flexibility is given up, the price will be higher. As long as the moral hazard issue is not involved, rigidity in contracting does not make sense.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

In order for the Department of Defense to maintain its effectiveness in this time of relative peace, new mechanisms must be explored that will allow for both efficient and effective allocation of scarce resources. This thesis has shown that the Mark Johnson model of multiple attribute analysis can be applied as such a tool.

Although this mechanism is not the silver bullet for solving all of the DOD's acquisition problems, it does have potential for use in many different facets of the process. As long as adequate competition does exist, and the imperatives for its application are carefully addressed, the mechanism can prove to be a valuable addition to the acquisition workforces toolbox. In the absence of competition, it can still be useful for indicating to the contractor the value attributes other than price add to the government, and can thereby allow the contractor the flexibility to increase the government's gain.

B. RECOMMENDATIONS

The only way to ascertain whether the mechanism would truly work in a real acquisition situation would be to test it in that situation. Therefore, the DOD should conduct a pilot program on a small scale to test its viability in certain settings. Through this limited application, the advantages of such a tool will become apparent and proponents will develop. This will also provide a core of trained personnel who understand the mechanism and can promote its usage in other areas.

C. ANSWERS TO THE RESEARCH QUESTIONS

Q: How can the Mark Johnson model be used in DOD contracting to increase the overall gain to the government?

A: By indicating to the contractor the key attributes (and their tradeoffs) that give benefit to the government and giving the contractor both the incentive and the flexibility to maximize those attributes, the overall gain to the government will be increased.

Q: What attributes should be considered key to a project?

A: Any attribute that can be readily identified as adding to or multiplying the benefit the DOD receives. These attributes may include, but are not limited to price, quality, reliability and timeliness.

Q: How can a relationship between the key elements be defined?

A: The easiest way to define the relationship is to fix all attributes at a certain level to establish a baseline.

From this point one of the attributes should be varied asking what would have to happen to the other attributes in order to maintain the same level of desirability as at the baseline. By establishing the tradeoff characteristics of the attributes, the relationship can be formally defined.

Q: Will streamlined contracting methods affect the availability of DOD contractors in the long run?

A: Maybe. The objective of the streamlining is to reduce the amount of regulations and oversight required in the contracting field. This ultimately should decrease the restrictions imposed on contractors and thereby increase the number of contractors willing to perform DOD contracts. However, as the DOD decreases the number of contracts let and mechanisms for limiting contractors profit levels are employed, the inefficient contractors will drop out of the DOD contracting arena, thereby decreasing the contracting base. The net effect of the increases and decreases is unknown, however, only the efficient firms will remain.

Q: Can the Baron/Myerson truth telling model be used with multiple attributes?

A: Yes. Presently the Baron/Myerson model addresses the attributes of Price and Quantity, both of which must be flexible in order for the model to be used. The model could also be applied to price and any other attribute, but in its present form cannot be used with more than two attributes.

D. SUGGESTIONS FOR FURTHER RESEARCH

The following areas merit further research.

1. The weakness of the Vickrey Auction in an area with little competition needs to be addressed. Developing a truth telling mechanism that is efficient in this environment is critical to the success of the Mark Johnson model. By altering the Baron/Myerson mechanism to include more than two attributes, and combining it with the utility function of the Mark Johnson model, the advantages of both models could be expounded. Research could be conducted into developing an effective combination of these two models.

2. This research examined four areas in which multiple attributes analysis was applicable and in which the Mark Johnson model could be employed. Further work could be done on expanding the application to other areas of the acquisition process.

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